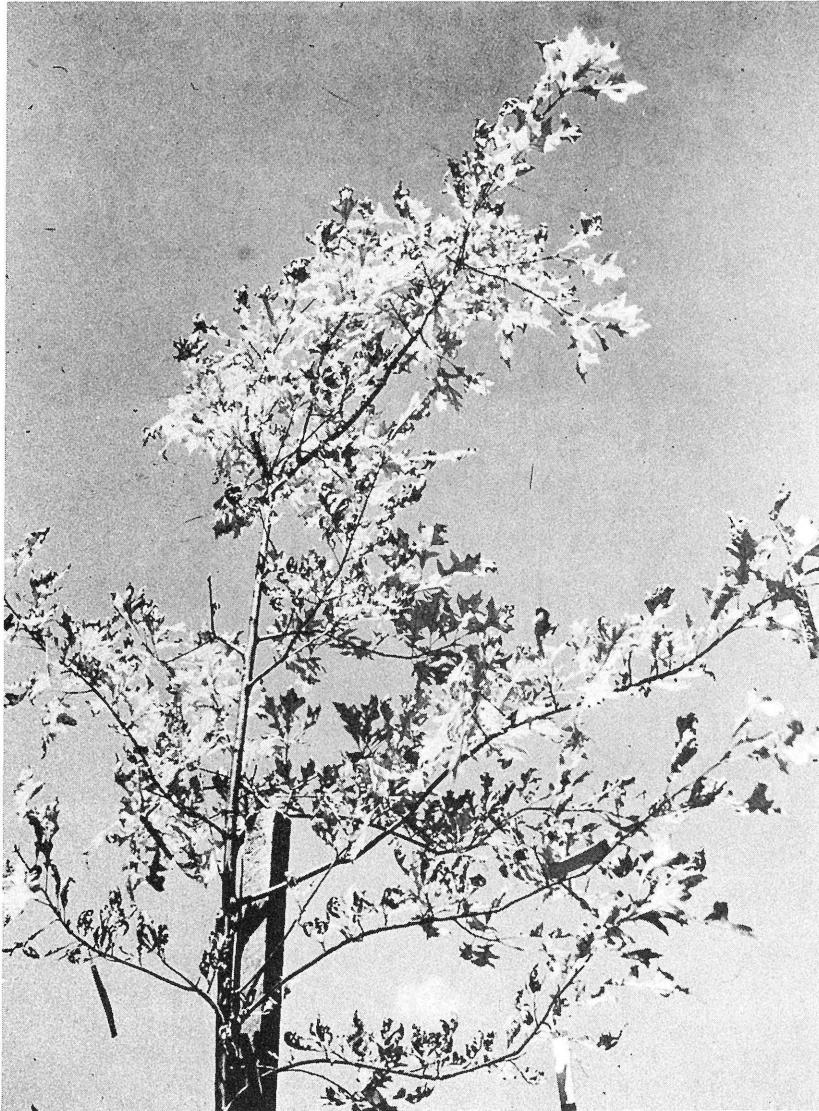


Correction of Lime Induced Chlorosis in Pin Oak



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CORRECTION OF LIME-INDUCED CHLOROSIS IN PIN OAK

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Introduction

Abnormal development of plants may be caused by nutritional imbalance, diseases, insect attack, or genetic factors. Often the symptoms are similar and the exact cause difficult to determine. Prerequisite to an attempt at correcting a particular plant abnormality is the diagnosis of the cause.

Presented here is an example of the use of a technique for detecting and identifying nutritional deficiencies, and the development of a successful treatment for the specific deficiency found.

Methods and Results

In the spring of 1958 several young pin oak trees located at the Ohio Agricultural Experiment Station, Wooster, Ohio, exhibited chlorosis in the foliage. The trees in this group ranged from 1.5 to 2 inches in diameter and from 8 to 12 feet in height. The color of the foliage on some trees was yellow, while on others the foliage was yellow-green or green (Fig. 1). The trees were growing in a well drained Wooster silt-loam soil.

The first step in attempting to establish the cause of the chlorotic condition was the selection of seven trees for experimental use. Three severely affected trees had leaves which were yellow in color with yellow-green veins and anthocyanin pigment apparent in the tips; two mildly affected trees had yellow-green leaves with dark green veins; and two trees were included which had leaves with a good green color.

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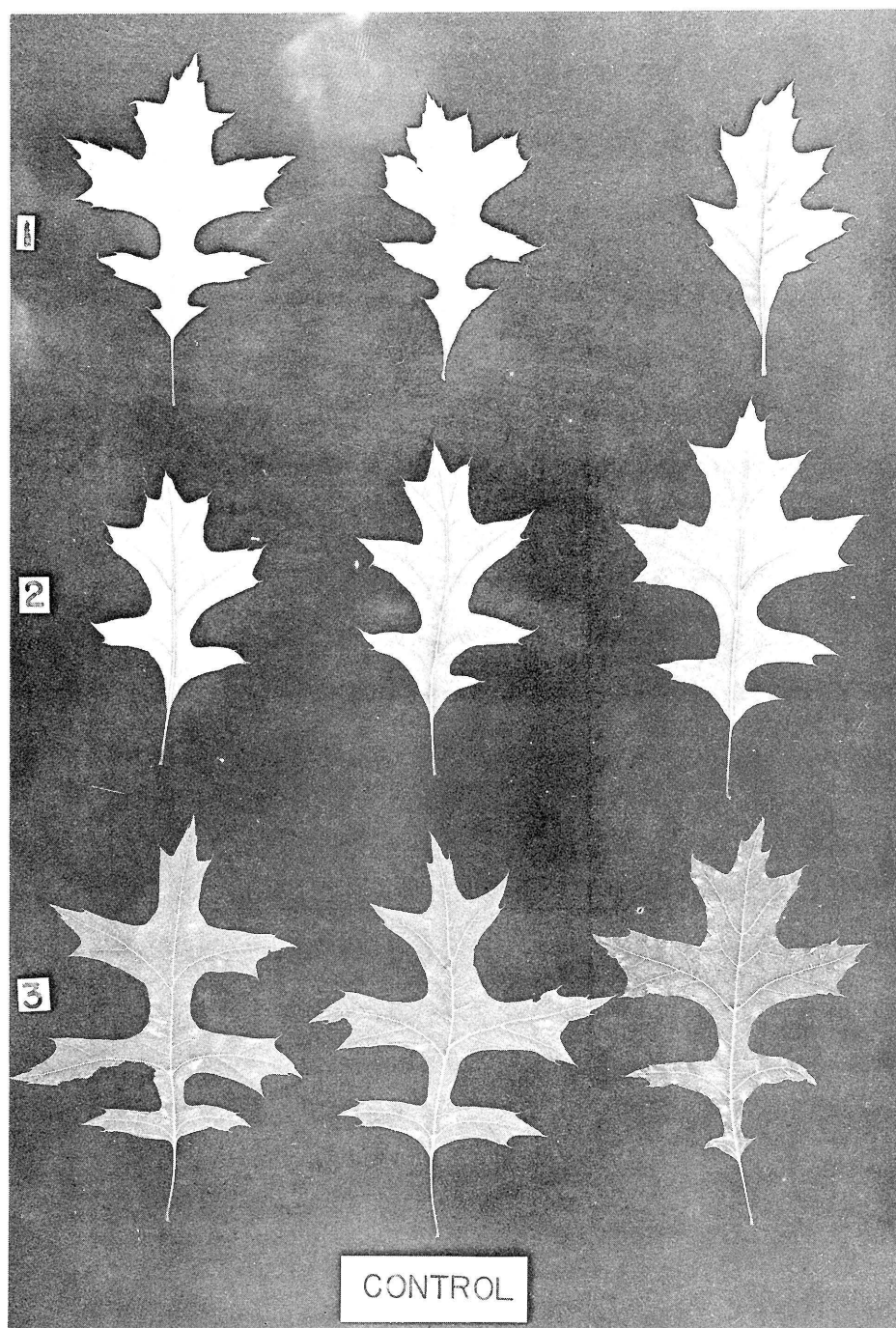


Fig. 1. Range in appearance of leaves from the three groups of pin oak trees prior to experimental treatment. 1 - yellow; 2 - yellow-green; and 3 - green.

In order to determine if a nutrient deficiency was causing the chlorosis, on May 29, 1958, ten twigs were tagged on each of the seven trees and the terminal leaves were treated by dipping them into one of the following solutions: 0.02 M FeSO_4 , 0.05 M $\text{Ca}(\text{NO}_3)_2$, 0.002 M ZnSO_4 , 0.05 M Na_2SO_4 , 0.1 M KNO_3 , 0.1 M NaCl , 0.1 M KH_2PO_4 , a dilute mixture of minor elements excluding iron, and a control solution containing a commercial wetting agent which was used throughout the series. Additional twigs were also treated a few days later with chelated iron at 500 ppm, and 0.01 N sulfuric acid. Deleterious affects in the form of spotty tissue injury were noted only for the calcium ion and the chelate* used.

Within four days after application, the leaves dipped in the iron solutions showed improvement; those leaves which were yellow began to turn green and by ten days had become green throughout (Fig. 2).

On the basis of these findings one of the yellow trees which was developing necrotic areas in the leaves and appeared to be on the verge of dying was treated with iron. A soil application of 19 grams of chelated iron in solution at 1,000 ppm was made on June 3, 1958 and repeated on June 5. Six days after iron was applied the veins had become greener and areas between the veins began to appear green. Within one month the yellow leaves were green and the new growth of stems and leaves was normal.

Soil tests showed that the pH of the soil around the trees ranged from 7.2 to 7.8. There was no difference in the pH of the soil to a depth of 18 inches. Inquiry disclosed that this normally acid soil had been heavily limed for experimental purposes a number of years earlier. On the hypothesis that the chlorosis was lime-induced, treatments were planned to lower the pH of the soil in the root zone of trees by the addition of sulfuric acid and flowers of sulfur. To determine the amount

*Sodium ferric ethylenediaminetetraacetate.

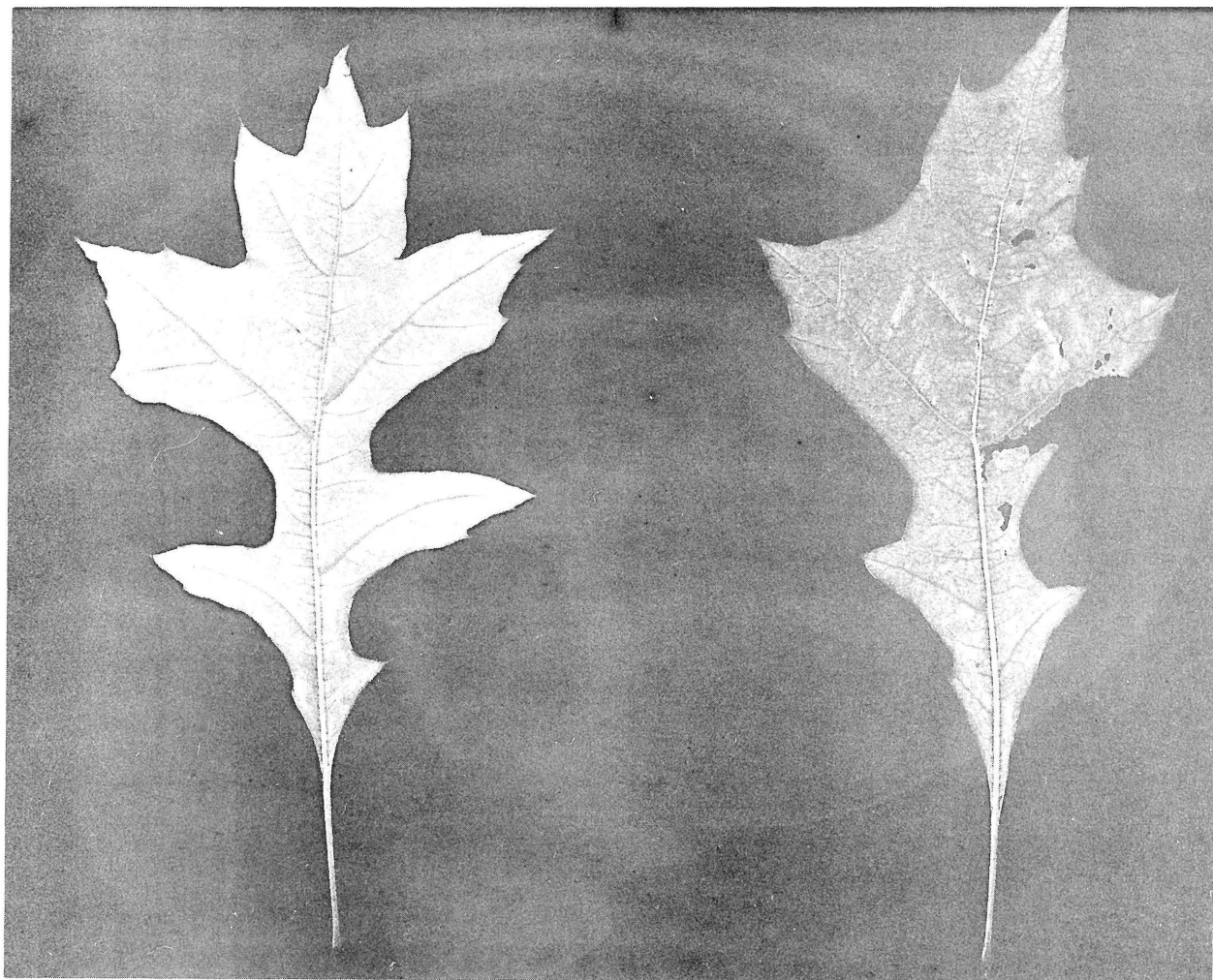


Fig. 2. Appearance of untreated leaves from the yellow trees (left) and adjacent leaves (right) ten days after being dipped in a ferrous sulfate solution.

of acid or equivalent sulfur needed to adjust the soil pH, 10 gram portions of soil were titrated with tenth normal H_2SO_4 (Fig. 3). It was found that the equivalent of about 40 ml. of concentrated acid per cubic foot of soil was required to reduce the pH to the desired level between 5.0 and 6.0.

On July 16, 19 liters of three normal sulfuric acid was applied to the soil in holes around each of two trees, and an equivalent amount of sulfur was spaded and thoroughly mixed into the soil in a band around two other trees. In each treatment there was a tree with yellow leaves and a tree with yellow-green leaves.

Within two weeks after the application the terminal buds broke and new leaves were beginning to appear on the trees treated with acid. At the end of six weeks as a result of new growth the yellow-leaved tree had good green foliage and was actively growing. The original yellow leaves had become necrotic and abscised. In the case of the yellow-green tree the original foliage was retained, and became a good green color. New leaves developed and stem elongation was evident.

In the trees treated with flowers of sulfur there was no noticeable response. The foliage remained light yellow in color to the end of the growing season, and necrosis was very evident in the yellow-leaved tree. The leaves of the yellow-green-leaved tree became progressively more yellow in color. There was no new growth evident in these trees or those trees of the experiment which had good green foliage but were untreated; this observation may indicate that stunting occurred even though foliar symptoms were absent.

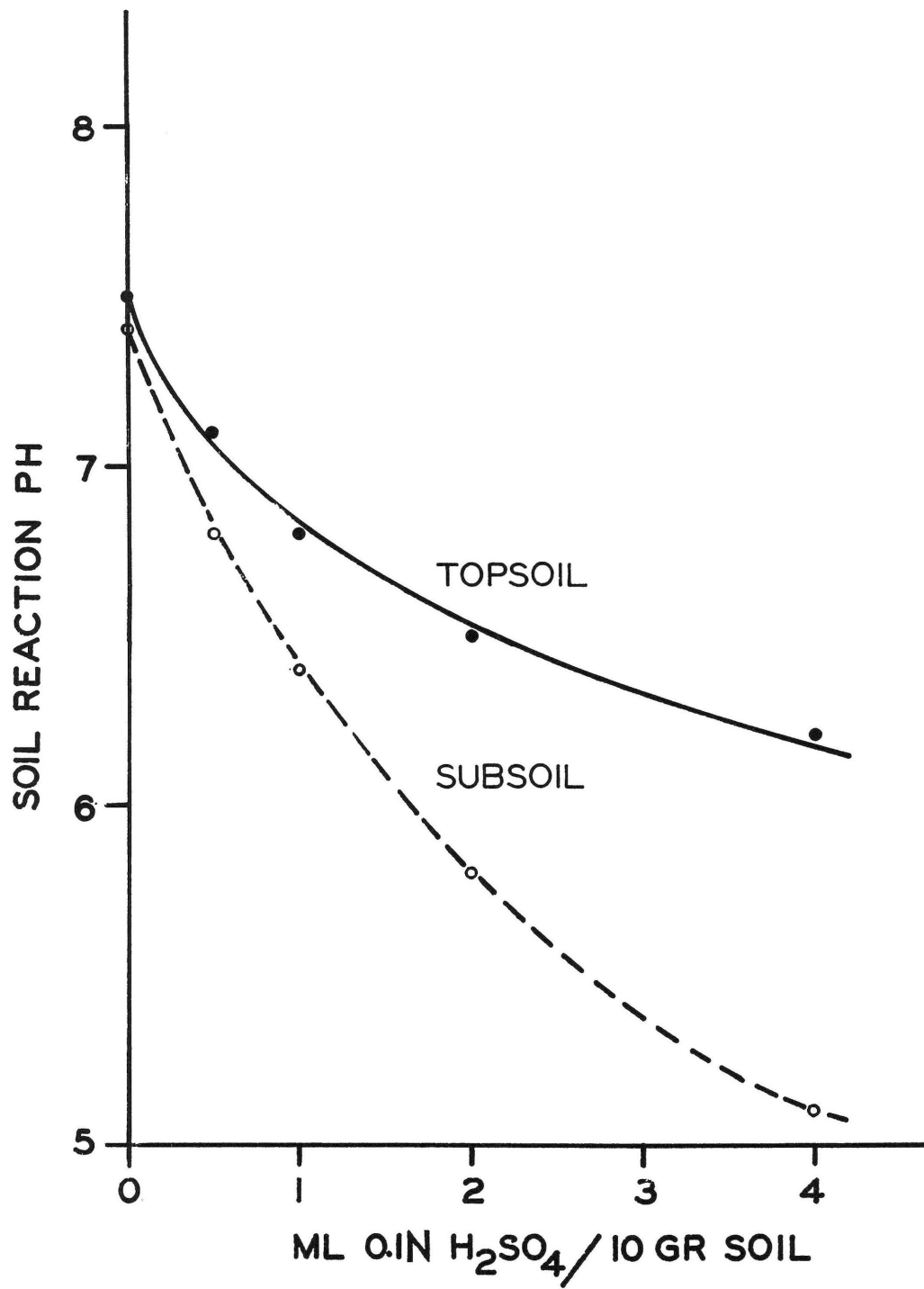


Fig. 3. Titration curve of soil samples taken from the root zone of the pin oak trees.

Summary and Discussion

The occurrence of chlorosis in pin oak has been recorded by other workers and is described as a condition where yellowing of the leaves appears between the veins, gradually includes the whole leaf, and finally causes a curling and dying of its outer margins. Further stages of decline causes a deformed and die-back condition of the branches (2). This condition has been observed and reported due to lime-induced iron deficiency (4). The chlorotic condition can be corrected by either spraying iron sulfate on the leaves or addition of sulfur and FeSO_4 to the soil (2). Recently chelates have been employed for the same purpose. Soil application of ferrous sulfate to supply iron is not effective because the iron is rapidly oxidized to unavailable form.

Brown (1) states that a continuous source of available iron appears necessary for the growth of all plants. The fact that iron chlorosis can be corrected in plants growing in the presence of the bicarbonate ion, excess heavy metal or excess phosphate, or in calcareous soils by applying an available source of iron to the soil would seem to indicate that iron deficiency is caused by a lack of available iron in the rooting medium. In contrast, McGeorge (3) reports that unavailability of iron within the plant is the chief cause of chlorosis on calcareous soils.

In the present experiment, the deficiency of iron was identified as the cause of chlorosis in pin oaks by a favorable response to foliar application of the element. Soil tests indicated that the condition was probably lime-induced.

Although the chlorosis was satisfactorily corrected by adding chelated iron to the soil, it was found that a reduction of the soil pH in itself was sufficient to adjust the availability of iron to the tree. It was

considered more important to adjust the medium in which a plant is growing rather than temporarily to supply iron. Titration of soil from the root-zone rather than tree diameter was the criterion used in making treatments. Acidification of the soil is less expensive and doubtless more permanent than application of chelates. Addition of sulfur to the soil did not deter the progressive severity of the chlorotic condition during the growing season; evidently its oxidation in the soil was too slow to lower the pH with the required speed once visual symptoms appeared. Sulfuric acid is corrosive and must be handled with care, but is very effective and rapid in correcting lime-induced iron chlorosis.

Bibliography

1. Brown, J. C. Iron chlorosis. Ann. Rev. Plant Physiology, 7:171-90, 1956.
2. Chadwick, L. C. 1936. Chlorosis in pin oak. Proceedings of the American Society of Horticultural Science 33:669-73.
3. McGeorge, W.T. 1948. Nutrient interrelations in lime-induced chlorosis as revealed by seedling tests and field experiments. Ariz. Agr. Expt. Sta. Tech. Bull. No. 116, 297-338.
4. Plant disease investigations. Kentucky Sta. Rpt., Pt. 1, pp. 15-18 , 1927.